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Environmental Effects of Dredging Technical Notes

USE OF SEABED DRIFTERS FOR LOCATING AND MONITORING DREDGED MATERIAL PLACEMENT SITES

PURPOSE: This note provides information on using seabed drifters (SBDs) to help locate optimum sites for placing dredged material, for both nearshore berms (feeder berms) and offshore mounds (stable berms). In addition, guidance is given for using SBDs to monitor potential sediment transport pathways at existing dredged material placement sites. Some of the information provided is based on results from DUCK 85 and SUPERDUCK, two large coastal processes experiments conducted during the fall of 1985 and 1986, respectively, on the outer banks of North Carolina. Seabed drifter investigations during SUPERDUCK were directed specifically toward offshore dredged material placement applications. Other guidance is based on monitoring associated with past and ongoing projects of Corps Districts.

BACKGROUND: This technical note is one of a series on monitoring of dredged material disposal sites. As mentioned in the first note of this series, "Acoustic Tools and Techniques for Physical Monitoring of Aquatic Dredged Material Disposal Sites" (Technical Note EEDP-01-10), increased use of near-shore disposal sites often requires additional monitoring. This is necessary to meet local, state, and Federal requirements to minimize adverse physical and biological impacts by determining the fate and stability of dredged material placed underwater.

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Introduction

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Predicting the path of transported sediments is difficult. The physics of sediment erosion and transport are not completely understood. The complex interactions between waves and currents which erode sediment and the lack of sufficient information on space and time variations of near-bottom currents which transport the material make the predictions of numerical models subject to debate. SBDs can provide low-cost documentation of bottom-current

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circulation and may indicate possible paths for sediment movement. Their predictive capabilities are limited, however, because direct correlations between SBD movement and bottom sediment movement are not available. The second major limitation is that the path taken by the SBD and the rates of movement along that path are not usually known, although tracking is possible, as discussed later. Still, SBDs have a wide, although qualitative application to problems in coastal engineering. The focus of this note is on using SBDs to locate and monitor nearshore dredged material placement sites.

Following a brief description of seabed drifters, methods of deployment and recovery are presented. Recommendations on how to best use SBDs for siting and monitoring both feeder berms and offshore disposal mounds follow.

Physical Characteristics of SBDs

SBDs are commercially available, umbrella-shaped, plastic drogues with plastic tails (Figure 1). Typical disk size is 18 cm with four 2-cm vent holes. A 55-cm-long tail is most often used. Because the plastic is slightly buoyant, brass weights are attached to the tail to keep the SBDs on or near the bottom. Experiments have shown that 14-g weights are sufficient for this purpose (Hands 1987). Flume tests have shown that SBDs move at various percentages of the mean current speed, ranging from 73 percent at 15 cm/sec to 85 percent at 50 cm/sec, approaching 91 percent as the current increases.

Assembled SBDs are bulky, so it is usually best to put them together at the study site. Assembly takes 1 to 2 min per drifter. A hammer or crimping tool is needed to attach the weights.

SBDs are usually deployed with a postage-paid, waterproof card (usually polyvinyl chloride paper) to identify the time and location of recovery. Persons recovering the SBD and attached card are asked to fill in time, date, and exact location of the recovery (Figure 2). Small maps printed on the cards may assist in identifying recovery points when few landmarks are available. The card surface must be suitable for writing on with pen or pencil.

Experience along US coasts has shown that the public will consistently report SBD recoveries without the inducement of a monetary reward. The satisfaction of participating in a scientific study with practical consequences appears to be sufficient motivation for most volunteers. Posters placed in local shops, marinas, and docks and local media exposure (television

18-cm-diameter
brightly colored disk
with four vents, 2-cm-diameter

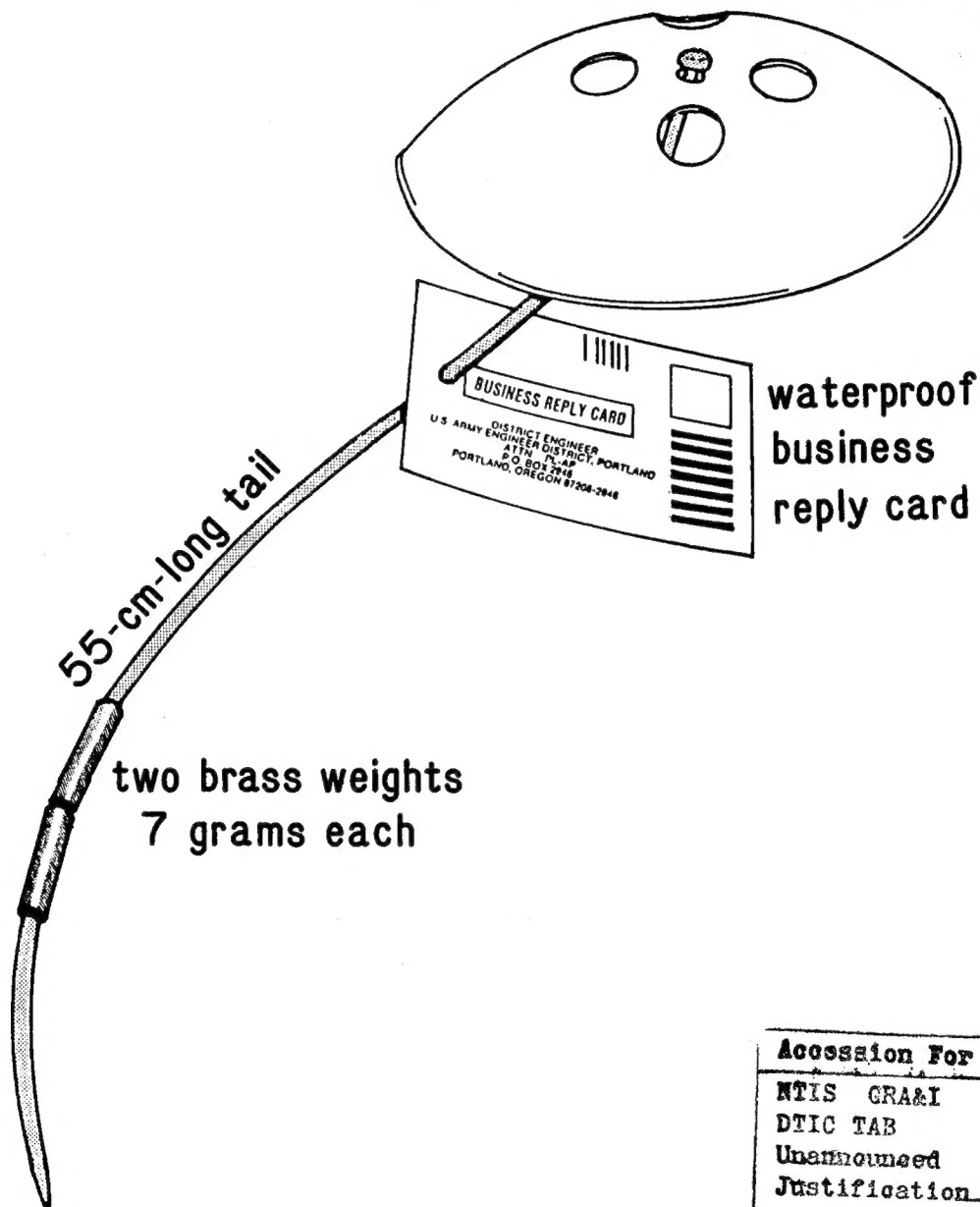


Figure 1. Seabed drifter

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WES FORM 2365-4, 1 July 87

This device is part of a scientific study of ocean currents conducted by the US Army Corps of Engineers. Please help by completing this questionnaire (in pencil or ball-point) and placing it in any convenient mailbox. Keep or dispose of device.

EXACT RECOVERY LOCATION: _____
 (May mark an X on the map) _____

DATE AND HOUR OF RECOVERY: _____

WAS THE CARD ATTACHED TO A PLASTIC STEM? YES NO
 WAS THE STEM ATTACHED TO THE 7-INCH DISC? YES NO

Thank you for this vital assistance. Do you want return information? _____

YOUR NAME AND ADDRESS _____

TELEPHONE _____

DEPARTMENT OF THE ARMY
 U. S. ARMY ENGINEER DISTRICT, MOBILE
 CORPS OF ENGINEERS, P.O. BOX 2288
 MOBILE, AL 36628-0001

OFFICIAL BUSINESS
 PENALTY FOR PRIVATE USE \$300

BUSINESS REPLY CARD
 FIRST CLASS PERMIT NO. 12062 WASHINGTON, D.C.

POSTAGE WILL BE PAID BY DEPARTMENT OF THE ARMY

COMMANDER
 U. S. ARMY ENGINEER DISTRICT, MOBILE
 CORPS OF ENGINEERS
 ATTN: SAMOP-ON
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Figure 2. Example of the waterproof information card used for a study near Dauphin Island, Alabama. The card can be customized for individual projects

and newspapers) alert the public to the nature of the study and provide instructions on what to do with the drifter and cards after recovery. Public participation is further motivated when the Corps follows up the voluntary return of an SBD card with a thank-you letter, describing the purpose of the project. In addition, public participation provides some low-cost public awareness of the Corps' role in attempting to solve coastal problems.

Deployment

SBDs are usually deployed in bundles of 25 to 30. A smaller number may make recovery of a statistically significant number of drifters difficult. More than 30 SBDs in a single bundle would be difficult to handle. Multiple releases of bundles of 25 to 30 are possible and may be used under certain situations described later. Typically, 25 to 30 individual SBDs are bundled together using 1/8-in. nylon (parachute) cord that is knotted to a salt ring (Figure 3). Recently, plastic cable ties have replaced the nylon cord, reducing the time needed to make the bundle. A piece of scrap metal or chain (approximately 2 to 5 lb) or a sandbag is used as weight to expedite descent. A second line tied to the weight is used to lower the weight and SBDs to the bottom. After 10 to 15 min, the salt ring dissolves, releasing the drifters at the bottom, after which time the weight can be recovered if desired. Should it not be practical to recover the weight, a bundle of SBDs with attached weight can safely free-fall through the water column.

Recovery

SBDs are usually recovered in two ways. For nearshore applications, the SBDs will wash up on shore and can simply be picked up. The other tested method of recovery is by trawling with a fishing boat. Sonic tags can be attached to the one or two of the SBDs to assist in recovery from fishing vessels or to track the path of individual SBDs. Sonic tags are small acoustical transmitters normally used to track fish. When the sonic tags are used in place of a weight on an SBD, they do not appear to adversely influence the motion of the SBD. The sonic-tagged SBDs can be tracked using a portable, directional hydrophone and receiver. Sonic tags cost \$150 each, the receiver costs \$1,400, and a hydrophone costs \$800 (1987 dollars).

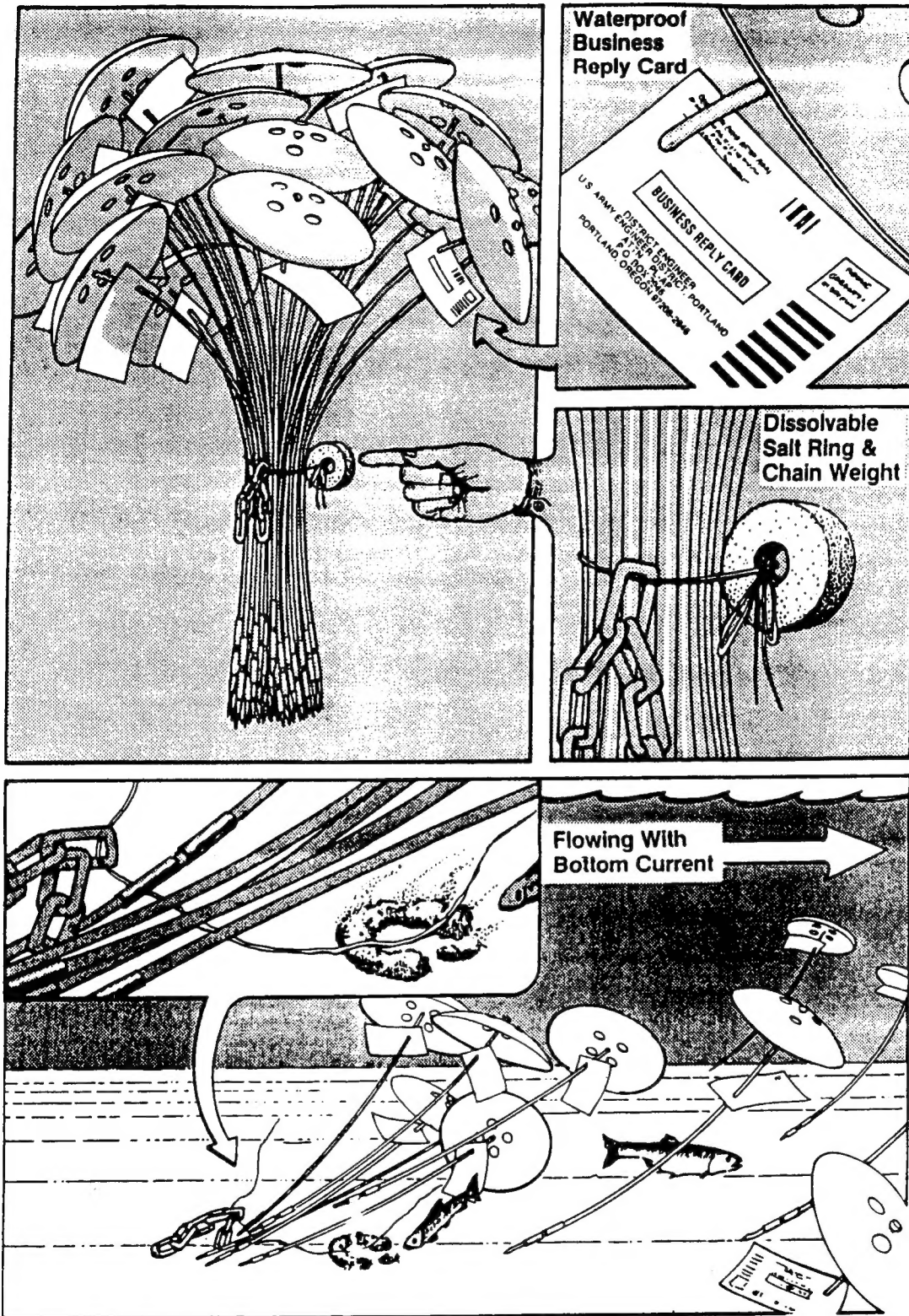


Figure 3. Seabed drifter deployment

Siting and Monitoring Feeder Berms

In the feeder berm concept, dredged sand is placed close to shore with the anticipation that the sand will remain in the nearshore sand prism and contribute to overall shore stability. Detailed guidance on design of feeder berms is not yet available. Monitored placements now under way will help develop a basis for design. Two monitored feeder berm projects have recently been constructed off the south shore of Long Island as part of the New York District's channel maintenance project at Fire Island and Jones Inlet, and a feeder berm was built off Sand Island, Alabama, as part of a National Demonstration project. SBDs are one part of the much larger monitoring effort at the Sand Island site. The Galveston District is now considering a feeder berm project near Brazos-Santiago Pass, Texas. An SBD study is planned to help locate the optimum site for sand placement. Many of the recommendations for that project are incorporated in this note.

SBDs have potential both to help determine the best feeder berm locations and to estimate in what direction the placed sediment will move. Studies before and after placement have value because the placed berm may alter the nearshore waves and currents to some degree. Whenever possible, SBDs should be used in conjunction with other measurements. Use of SBD drifter data without some knowledge of the forces that influence SBD movement (i.e., currents, waves, and wind) makes interpretation of these data very difficult.

Long-term current measurements at several elevations in the water column and at several locations at a site are most desirable, but may be too expensive for many projects. A less expensive alternative is to take current measurements over a tidal cycle at several locations during the periods SBDs are released. This would provide information on the tidal-induced current field but would not document wave-induced currents.

Wave data, both long-term and during the SBD releases, are also desirable when studying feeder berms. Long-term wave data indicate where placed sediment may move. Short-term measurements during SBD releases may aid in understanding SBD movements. While Wave Information Study-hindcasted wave data (Brooks and Corson 1984, McAneny 1986) are relatively inexpensive, most long-term measurements are expensive. Short-term, quality measurements are not practical in most cases due to the effort and expense associated with installation of a wave gage. Often, the only practical method of getting wave data

is from visual observations, which is of fairly low reliability. Aerial photography can document wave refraction and diffraction patterns at a particular instant in time.

Wind data during deployment are often available from local airports and military or Coast Guard installations. A record of wind speed, duration, and direction for the extent of the SBD release and recovery period is usually easy to obtain. Recent studies have demonstrated the importance of local winds in driving nearshore currents (Hubertz 1984) and controlling the pattern of SBD returns (Hands 1987).

One of the most important aspects of using SBDs is deciding when to deploy them. Deploying SBDs over a variety of wind, wave, and tide conditions capable of transporting the placed sediments is desirable. However, the logistics of operating on short notice under potentially stormy conditions makes this difficult. A more reasonable scenario may be to identify a time period(s), say 1 to 2 months, when placed sediment is likely to move. During that time, intensive deployments could be made at several sites over 3- to 5-day periods. One deployment should be planned for the spring tide conditions when tidal currents are maximum. For example, in the siting plan for the Brazos-Santiago Pass project, 10 separate sets of releases at each of five sites over a variety of wind, wave, and tide conditions are planned. This plan requires 50 releases with 30 SBDs in each bundle for a total of 1,500 SBDs.

SBDs are usually released from a boat. Electronic positioning (preferably microwave, although well-calibrated LORAN C may be acceptable) is needed to determine location of the release sites. The same vessel can also be used to deploy current meters, track sonic tags attached to the drifters, and, possibly, trawl for drifters.

To ensure prompt, accurate recording of the location and time of SBD arrival onshore, persons involved in the operation should monitor the shore for at least a 24-hr period after deployment. A vehicle capable of traversing the beach, usually a four-wheel-drive or all-terrain vehicle with an accurate odometer, should be available. Special authorization from local authorities may be needed to use a vehicle on the beach. As mentioned earlier, a public awareness program will increase the likelihood of volunteer data reporting.

Ongoing studies indicate that SBDs tend to arrive onshore during rising tides, particularly during the last few hours before high tide. Experience

from the DUCK Experiments (Hands 1987) has shown that high percentages of the drifters can be recovered (>80 percent) and that many will arrive onshore simultaneously (within 1 hr). Under favorable conditions (swell waves, off-shore winds, and onshore bottom currents), SBDs released from 1,500 ft off-shore came ashore in 6 hr. Thus, it may be essential that, following SBD releases, paid participants keep searching every few hours for several miles up and down coast from the release point.

While a majority of the SBDs may be recovered within a few miles of the release point, some travel considerable distances. Figure 4 shows the distribution of SBD returns based on deployment of 1,500 SBDs from six release sites on five separate occasions over 2 months at the Sand Island site near Mobile, Ala. Although the environmental conditions have not as yet been strong enough to cause significant movement of the berm, when the berm does move, these data should allow better interpretation of where the sand is moving.

The cost of the SBDs is usually only a small portion of the total cost of a comprehensive study. For example, less than 10 percent of the cost of the Brazos-Santiago Pass study designated for locating the feeder berm site was for the 1,500 SBDs (approximately \$3.00 each).

When monitoring existing feeder berms, SBDs can play a supportive role to other methods of monitoring sediment dispersion. Changes in bathymetry and beach profiles, along with sediment sampling and side-scan sonar, are important techniques for documenting berm movement. Monitoring of the forcing functions, waves, and currents is recommended. The monitoring guidelines (Fredette et al., in preparation) and Technical Note EEDP-01-10 on acoustic tools provide guidance in this area.

Siting and Monitoring Offshore Berms

In addition to being potentially useful tools for siting and monitoring feeder berms, SBDs also have potential for siting and monitoring offshore sites, both stable berms (a permanent mound formed by placing dredged material at a specific location) and dispersive sites. Many of the methods and techniques used for monitoring feeder berms apply to other offshore areas as well. Usually, recoveries from the beach become less important, and recoveries from trawling become more important. Tracking SBDs with sonic transmitters to determine their path and locate optimum areas for trawling will also become more important.

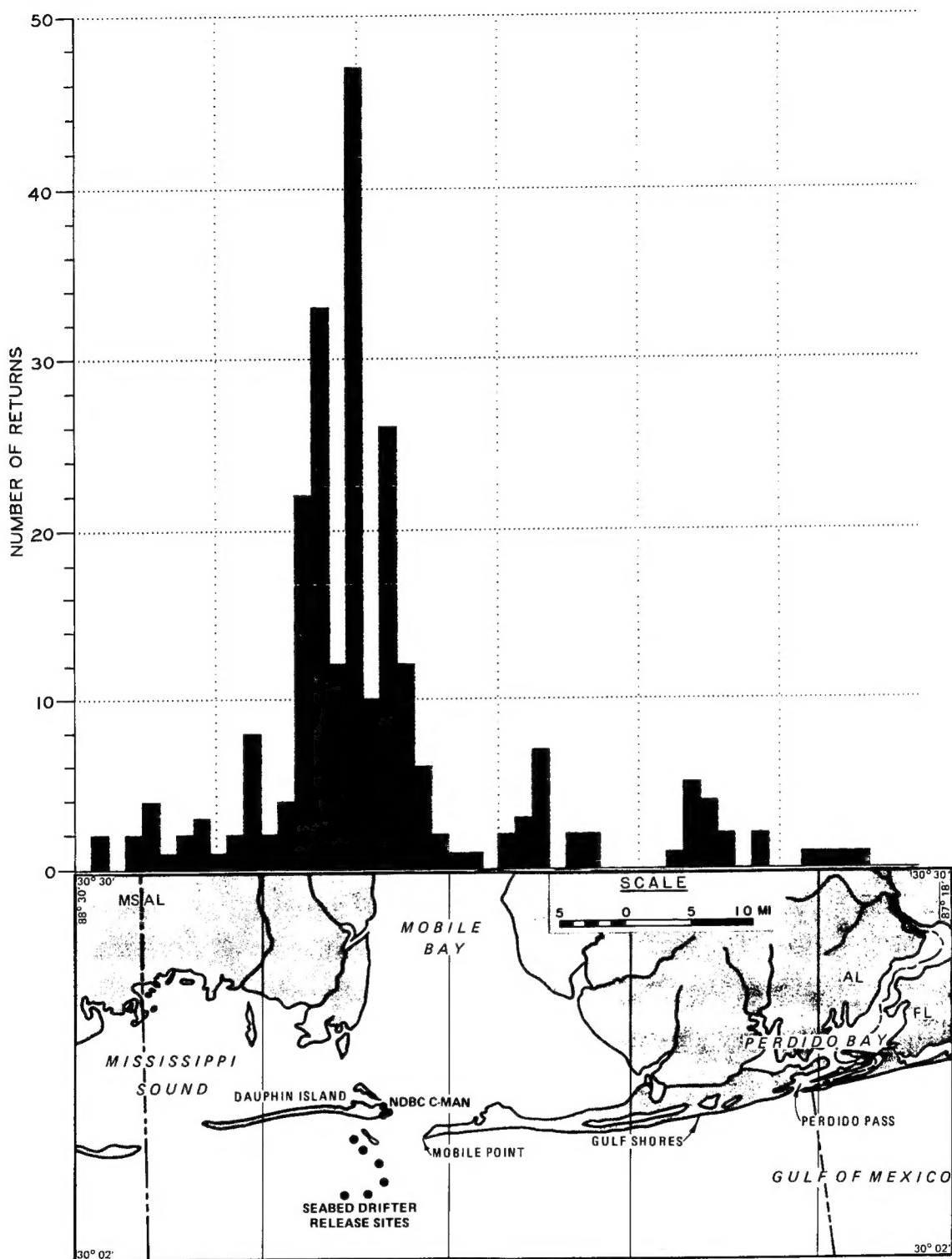


Figure 4. Longshore distribution of 191 Sand Island SBDs recovered as of 7 August 1987. A total of 1,500 drifters released between 3 March and 5 May 1987

Because the percentages of recovery are usually lower for deeper water, more drifters should be deployed. The number released will depend on the number of releases and the intensity of the search effort. When a series of closely spaced releases are planned along with sonic tracking and trawling, release quantities of 100 to 200 may be appropriate. For releases where local fishing efforts will be the primary source of recovery, larger releases of up to 300 to 1,000 or more SBDs may be necessary.

As with nearshore releases, bottom-current measurements will help to determine probable SBD paths and indicate potential areas for trawl searches. Electronic positioning for release and search vessels is also a requirement. In certain locations, tracking may be crucial. For example, SBDs released close to an inlet may travel in and out of the inlet on tidal currents before washing ashore some distance away from the inlet. Closely tracking the SBDs would provide data on whether the SBDs are entering the inlet. In these cases, placing the hydrophone on a very maneuverable boat or using two vessels, each with a hydrophone and receiver, have been suggested to more closely monitor SBD movements (Hicks 1986).

A potentially much more effective method of searching for SBDs may be to use side-scan sonar. Most commercially available sonic tags transmit at 74 kHz, which cannot be readily detected by 100-kHz commercial side-scan sonars. The Coastal Engineering Research Center of the US Army Engineer Waterways Experiment Station has had initial success with side-scan sonar detection of 100-kHz sonic tags. This new development should make tracking easier, faster, and more reliable.

The Portland District used SBDs to help determine whether sediments disposed in a site not far from the Siuslaw River entrance were making their way back into the inlet (Hicks 1986). Based on the pattern of SBD recoveries, current meter measurements, and surface dye movements during disposal operations, the Portland District recommended that the disposal site be moved farther offshore to deeper water.

Summary and Recommendations

SBDs are inexpensive bottom current-following drogues that show integrated bottom-current paths. With careful application they can give an indication of the potential paths of sediment transport. Thus, SBDs are promising

tools for siting and monitoring both feeder berms and offshore sites, where movement of placed sediments is important. Their relatively low cost and high visibility in the public eye are the primary advantages. Lack of definite correlation between sediment movement and SBD movement and uncertainty about the path SBDs have followed are the major limitations. Consequently, SBD data should always be supplemented with as many coastal process measurements (such as currents, waves, and winds) as possible.

Existing and future projects will provide additional data on SBD effectiveness. When sufficient information becomes available, it will be included in a report or an updated version of this note.

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